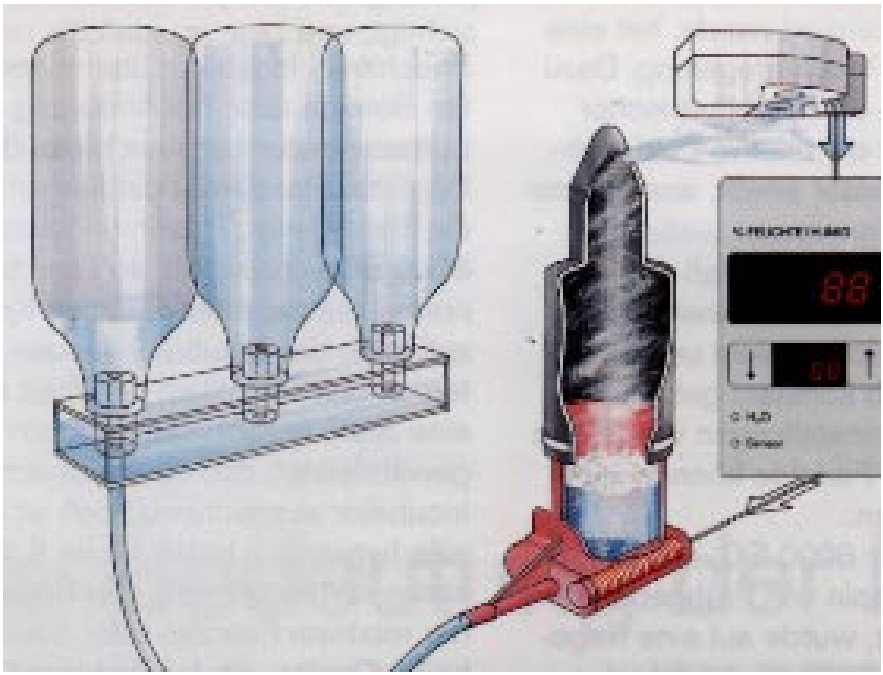
Humidification without risk of infection in the Dräger Incubator 8000



4-172-91

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This article is submitted to
"Archives of Disease in Cildhood"

Introduction

The advantages of maintaining a newborn pre-term baby's temperature have been well recognised for over 100 years. Tarnier and Budin published results in the 1880s showing a drop in infant mortality for those infants weighing less than 2000 grammes following the introduction of incubators and gastric feeding [1]. In the first neonatal text, »The Nurseling«, Budin desribed a reduction in mortality of over 50 % of those babies cared for in an incubator [2].

Infant's Temperature and Survival Rate

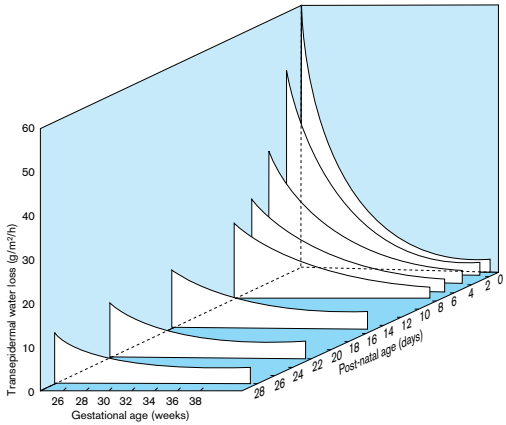
rectal temperature			survival rate
32.5 °C	to	33.5 °C	10 %
36.0 °C	to	37.0 °C	77%
"The Nurseling"		Piere Budin	1907

However, this experience was not universal and in New York in 1900, Henry Dwight Chapin reported 100 % mortality in 73 pre-term infants nursed in incubators and proclaimed »what we give in one factor - heat - we lose in a vital factor, that is fresh air, and I think the use of incubators should be abandoned entirely« [3].

The need to keep babies warm was not fully appreciated in the first half of this century until the work of Silverman again demonstrated an increased survival in pre-term babies nursed in incubators with their temperature raised to 85 to 89 °F (29.5 °C - 31.6 °C) [4]. While Silvermann found the survival of infants increased when their temperature was maintained, in a study controlling environmental temperature but varying humidity, he found no change in survivial [5]. Humidification of incubators, therefore, became increasingly unpopular when it was suggested that this contributed to infection and did not, itself, improve survival.

With the increasing number of extremely low birth infants that are cared for in most modern neonatal units, the ability to maintain the infant's temperature using unhumidified incubators has become a major problem. The concern of most neonatologists [6][7] that high humidity increases the risk of infection has made them reluctant to employ humidified incubators in their nurseries, despite the understanding that with a poorly developed epidermis, fluid losses from an infant of less than 1 kg may exceed 200 mls per day [8].

Transepidermal Water Loss in Newborns



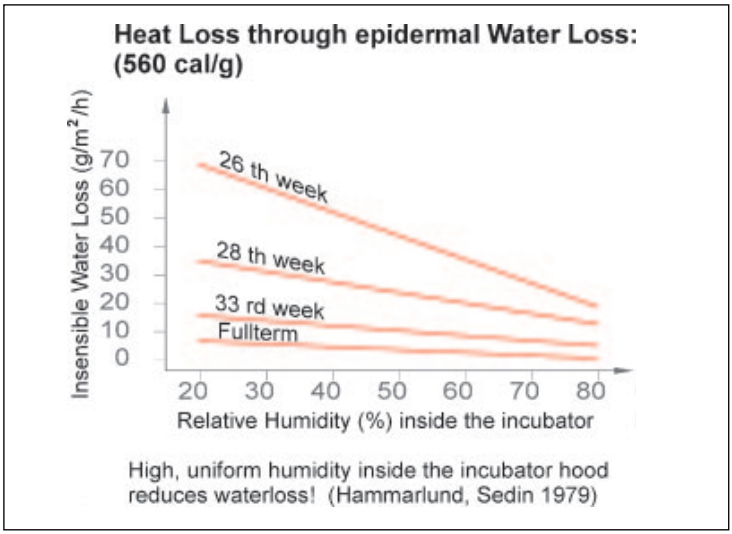
Premature babies with low gestational age show excessive water loss during the first days after birth and therefore, high heat loss. (Hammarlund, Sedin, Strömberg 1983)

In their paper in 1985, Harpin and Rutter recommend the use of incubator humidification for infants of less than 30 weeks gestation but also point out that the humidifier reservoir frequently became contaminated with bacteria, e.g. pseudomonas [7].
The introduction of infection into the incubator by humidification mechanisms, therefore, remains a concern.

Evaporative water loss from the skin in babies of less than 31 weeks gestation is often the single most important channel of obligatory heat loss from the skin during the first ten days of life. Water loss of an infant of 26 weeks gestation may be as great as 100 ml/kg/day while in infants of even lower gestation, the water loss will be greater [8] [9].In infants of 25 weeks nursed in an ambient humidity of 20 %, water losses exceed 200 mls/kg/day.

The infant's temperature may be maintained by increasing the environmental temperature but, in the smallest infants, this will require an environmental temperature significantly higher than 37 °C and even at 39 °C - the maximum temperature for modern incubators - there will be a significant heat loss in the most pre-term infants. Temperatures of this degree are difficult to maintain within narrow limits when the infant's environment is frequently being invaded in order to carry out procedures. It also requires a high flow of dry heated air.

The fluid losses can be replaced by additional fluid intake. However, fluid balances in these infants are extremely difficult unless they are frequently weighed and there is evidence that differences of as little as 2 ml/kg/hour of net fluid intake can significantly increase the risks of congestive failure due to patent ductus arteriosus and of necrotising enterocolitis in infants weighing less than 1.5 kg with respiratory distress [10] [11].



High, uniform humidity inside the incubator hood reduces waterloss! (Hammarlund, Sedin 1979)

Sedin and Hammarlund recommended in their publication [12] to use high relative humidity inside the incubator to reduce the huge fluid supply.

Objectives

In order to answer the question of whether increased humidity in these extremely small and vulnerable infants increased the risk of introducing infection when using a system that employed a water boiler and an electronic humidity servo-control mechanism to supply humidity as against the more traditional incubator humidifier, we undertook a study using the Dräger 8000 intensive care incubator to ascertain whether contamination of the water supply of the humidifier led to contamination of the infant's environment.

Methods

The Dräger 8000 intensive care incubator uses a humidification system with three bottles which supply water to a boiler which supplies steam to humidify the incubator. The boiler power is controlled by an electronic humidity servo controller using humidity gauges (see fig.1).

The incubator was set up to run at 37 °C with a humidity of 50 %. Initial swabs, settle plates and contact plates were taken to ensure that the incubator environment was sterile at the outset. None of these samples yielded any growth.

An overnight broth culture of pseudomonas aeruginosa was added to each of the incubator's three water bottles to achieve an inoculum density of around 10^6 colony forming units per millilitre (cfu/ml). Every day for seven days, the incubator environment was sampled using four contact plates and one settle plate. The settle plate was exposed on the base of the incubator for one hour. The contact plates were

used to sample the walls and roof of the incubator. These nutrient agar plates were incubated for 48 hours in air at 37 °C. In addition the necks of the water bottles were swabbed and this sample was examined to establish whether the test organism was still recoverable.

The incubator was thoroughly cleaned (according to the protocol in use at All Saints' Hospital, Neonatal Unit) and the water bottles sterilized before the trial was repeated. The other organisms used were: Escherichia coli, Staphylococcus epidermididis and Candida species (see table 1).

Results

Results are shown in table 2. These show that although three out of the four organisms were still isolatable from the water at the end of the study period and that, during the study period, the swabs taken from around the neck of the water bottle were contaminated with the organisms in three out of four cases, **at no stage were the organisms able to get into the incubator itself.**

Discussion

This study has shown that humidification of the incubator using the Dräger system does not, in itself, increase the risks of a very small infant becoming colonised or infected with organisms which may contaminate the water supply. It is known that a 50 % increase in humidification will halve the insensible water loss in these infants. It is also known that the stability of an infant's temperature is better in a humidified incubator.

The reduction of insensible water losses must be a preferable option in improving the baby's fluid balance and maintaining the temperature to increasing their environmental temperature and the potential danger of increasing their fluid intake.

Table 1
Organisms with inoculum densities in the incubator water supply

Test Organism	**Inoculum Density** (cfu/ml)
Pseudomonas aeruginosa	$2x10^3$
Pseudomonas aeruginosa	6×10^6
Escherichia coli	5×10^6
Staphylococcus epidermidis	5×10^6
Candida albicans	2×10^6

Table 2
Results-cultures from the incubator

TEST ORGANISM	CONTACT PLATES	SETTLE PLATES	SWABS	WATER RESERVOIR DAY 7
Pseudomonas aeruginosa ($2x10^3$)	N	N	N	N
Pseudomonas aeruginosa (2×10^6)	N	N	+ 1,2,3	+
Escherichia coli (5×10^6)	N	N	+ 1 only	+
Staphylococcus epidermidis (5×10^6)	N	N	N	N
Candida albicans (2×10^6)	N	N	+ 1 - 7	+

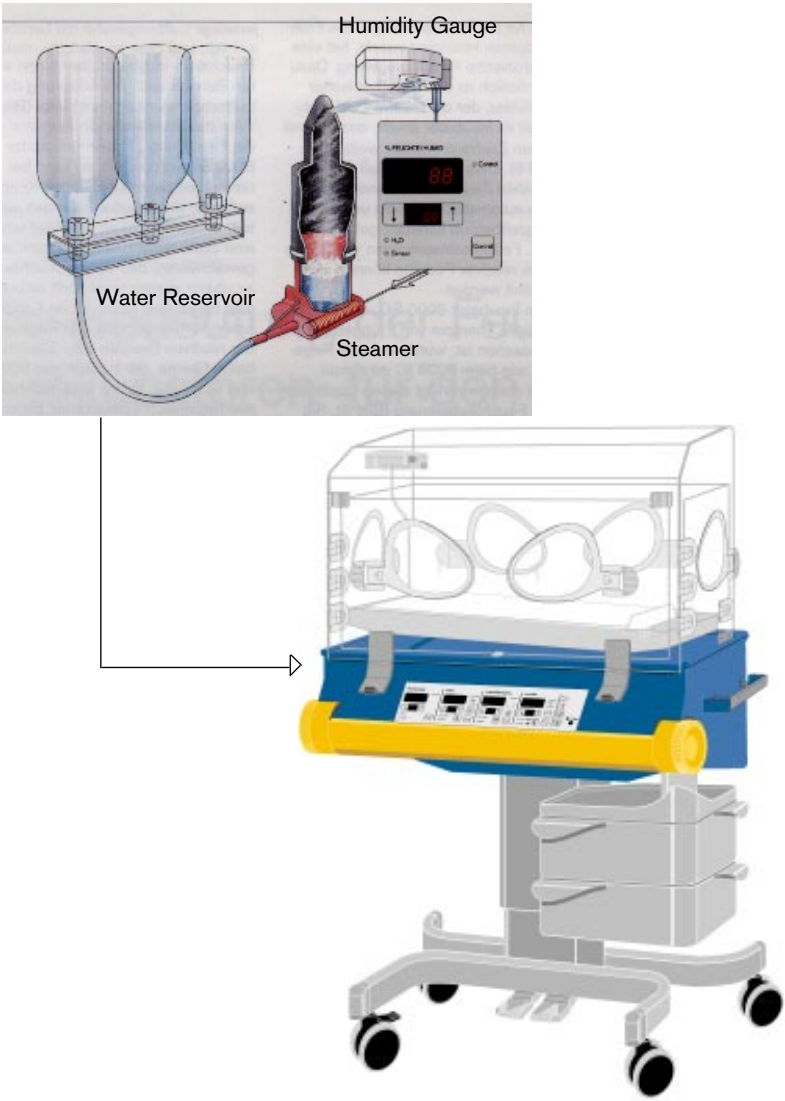
Key

N = No growth of test organism
\+ = Growth of test organism
1,2 etc. = Day of test period on which growth occured

Note

1 Sphingomonas paucimobilis (an organism often found associated with water containing equipment in a hospital environment) was isolated from the water.

Fig 1
Humidification system used
in Dräger Incubator 8000 series



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